EXPANDED VERSION

NASA/DoD Aerospace Knowledge Diffusion Research Project

IAF-94-P.1.301

Paper Forty Three

The Role of Information Resource Training in Aerospace Education

Paper Presented at the 45th Congress of the International Astronautical Federation (IAF) held October 9-14, 1994, Jerusalem, Israel

Barbara Lawrence
AIAA AEROPLUS ACCESS
New York, New York

Thomas E. Pinelli
NASA Langley Research Center
Hampton, Virginia

Rebecca O. Barclay
Rensselaer Polytechnic Institute
Troy, New York

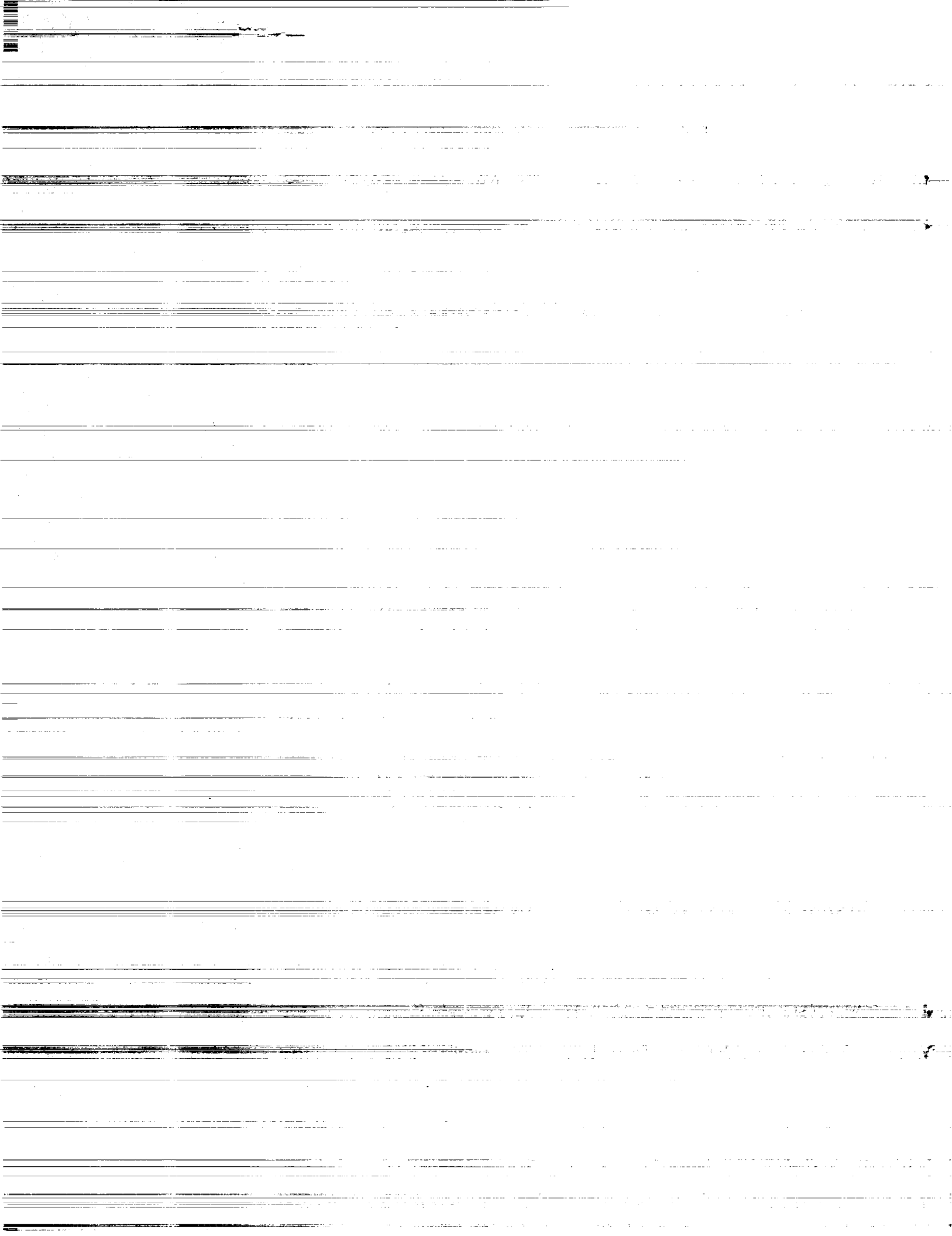
John M. Kennedy
Indiana University
Bloomington, Indiana

Karen Holloway
AIAA AEROPLUS ACCESS
New York, New York

National Aeronautics and Space Administration

Department of Defense

INDIANA UNIVERSITY



The Role of Information Resource Instruction in Aerospace Education[1]

Barbara Lawrence, Thomas E. Pinelli, Rebecca O. Barclay, John M. Kennedy, and Karen Holloway

ABSTRACT

Information resource instruction for undergraduate aerospace engineering students has traditionally been limited to an occasional part of the education process -- a written paper required in the capstone design course or a library tour. Efforts to encourage the use of aerospace literature and information resources have been made in the past decade, with a recent push from information and, especially, networking technology. This paper presents data from a survey of U.S. aerospace engineering students regarding their instruction in the use of information resources. We find that more than 25% of the students surveyed had had no instruction in technical communications skills or the use of information resources. We consider the need for instruction in the use of information resources and technical communications skills and the opportunities presented for improvement.

INTRODUCTION

The aerospace industry has become global in scope and collaborative in nature. Given the multidisciplinary nature of aerospace work, economic pressures and facilitating communications technologies are increasing the motivation and the potential for team work styles. Meanwhile, aerospace educators are feeling pressure to keep curricula up to date while continuing to teach the basics, leaving little time to emphasize communications skills. Yet these skills are crucial for engineers to perform effectively in the workplace.

In this paper, we first discuss some past efforts at educating students in the use of information resources. Next, we present data from a study of aerospace engineering students that solicited their views on the importance of information use and communications skills, the instruction they have received in these skills, and the perceived helpfulness of the instruction. We also provide data about their use of information resources and products, their use of computers and electronic networks, and their use of libraries. In closing, we suggest that additional research into communications skills instruction and its relevance for workplace communications is needed.

BACKGROUND

Instructing students in the use of information resources within aerospace education has been linked to two threads. One is the preparation of a paper in the capstone design engineering class. The other is in conjunction with the introduction of information technology. The American Institute of Aeronautics and Astronautics (AIAA) and Dialog Information Services collaborated on a Classroom Instruction Program for the provision of online access to the AIAA Aerospace Database [1]. Several papers presented at the 45th Congress of the International Astronautical Federation (IAF) address the application of information technology to education, yet most of these deal with the design of communication networks, and only secondarily with access to information resources or with improving communications skills. Pelton [2] envisioned an electronic tutor system on a global network, which would include a multilingual encyclopedia and education

---

[1] This paper is the expanded version of the one presented at the 45th Congress of the International Astronautical Federation held in Jerusalem, Israel, October 9-14, 1994.

videos. Willekens and Abrams [3] of ESA described a design project undertaken by students of the International Space University. The objectives would be to facilitate communication, distance education, and access to an electronic library. No particular information resources were identified with this library. Lo and other faculty of the Aerospace Institute of the Berlin University of Technology [4] described a research project to build a tutorial system with carefully defined data bases at its core. All of these laudable efforts would benefit from a better understanding of the use of existing information resources. An improved understanding would help students trained with the assistance of a particular technology implementation to be better able to transfer their skills in information retrieval and use to their future work environments.

METHODS AND SAMPLE DEMOGRAPHICS

As a Phase 3 activity of the *NASA/DoD Aerospace Knowledge Diffusion Research Project,* student members of the AIAA were surveyed in March 1993 [5]. Specifically, we examined (1) students' career choices, including the factors leading to that choice, satisfaction with the career choice, and career-related goals and aspirations, and (2) their communications behavior, including the instruction they receive as part of their undergraduate aerospace engineering education, their use of selected information sources and products, their use of computers and electronic networks, and their use of libraries. This work follows up on an earlier study of enrollees in an undergraduate capstone design course in 39 universities, designed to measure the information-seeking behavior and technical communications skills of undergraduates [6].

Self-administered (self-reported) questionnaires were sent to a sample of 4300 aerospace engineering students who were members of the AIAA. The questionnaire and a cover letter on NASA stationery were mailed from the NASA Langley Research Center during spring 1993. By the completion date of September 1993, 1673 AIAA student members had returned the questionnaire. Because of the summer vacation period, only one mailing was possible. After reducing the sample size for incorrect addresses and other mailing problems, the response rate for the survey was 42%. This rate is very acceptable for a student survey with only one mailing.

The AIAA has both undergraduate and graduate student members (table 1). Most respondents were undergraduates (948 or 57%) although 707 graduate students responded. Males outnumbered females approximately five to one. The proportion of females is greater among undergraduates, and the gender distribution is very similar (within two percentage points) to the distribution in our earlier survey of senior aerospace engineering students [6]. There appear to be substantial differences between the undergraduate and graduate students in terms of the percentages of students whose native language is not English and who are not native U.S. citizens. Each difference is about 10 percentage points. Over one-fourth of the graduate students are not native U.S. citizens, and almost one-fourth do not consider English their native language.

Limitations of the Study

We do not assume that these numbers reflect the demographic composition of all aerospace engineering students in the U.S. because there are probably differences between the students who join the AIAA and those who do not. In particular, non U.S.-native students are probably less likely to join a U.S. aerospace professional society than are native U.S. citizens. There may be smaller or larger gender and family income differences among all aerospace students, but the degree of difference, if any, cannot be determined. In later analyses, we intend to

examine the differences in the responses to two questions by characteristics of the students, including language, gender, and citizenship.

Table 1. Survey Demographics
[n = 1673]

Demographics	Percentages	Number
Gender		
Female	16.0	276
Male	84.0	1447
Educational Status		
Undergraduate	**55.0**	**948**
Freshman	4.1	71
Sophomore	7.4	127
Junior	12.7	219
Senior	30.8	531
Graduate	**41.0**	**707**
Other	4.0	70
Educational Preparation As		
An Engineer	92.8	1600
A Scientist	4.1	71
Other	3.1	54
Native (First) Language		
English	82.8	1430
Chinese	3.6	62
Japanese	0.5	9
Korean	1.0	17
Spanish	2.2	38
Other	9.9	171
Native Country		
China	0.9	16
Japan	0.5	9
Korea	1.2	21
Taiwan	1.6	27
US	79.8	1376
Other	16.0	276
US Citizen		
Yes	87.5	1509
No	12.5	216

Career Goals

About two-thirds of the student respondents indicated a preference for working in industry upon graduation. About 32% selected government, and about 15% selected academia as the type of organization where they plan to work upon graduation. About 60% of the students indicated that they had made their decision to become an aerospace engineer while they were in high school. About 23% indicated that they had made the career decision either when they started college (12%)

or after they had started college (11%). About 44% of the students stated that, with respect to their career decision, they feel about the same level of satisfaction now as when they first decided to become an engineer. About 29% indicated that they were happier now with their career choice, and about 27% indicated that they were less happy now than when they first made their decision.

Student respondents were asked to rate the importance of 15 goals or aspirations to career success. These goals and aspirations were grouped into three categories: engineering, science, and management-oriented. Those factors related to the engineering aspects of their careers were most important to the student respondents. About 85% rated the opportunity to explore new ideas about technology or systems very important for a successful career. Two other factors, working on complex technical problems (66%) and working on projects that require learning new technical knowledge (70%) were rated very important by students. Establishing a reputation outside the organization as an authority in the field was far less important to this group of students. Finally, the AIAA student members in this survey do not think that management achievements are as important to a successful career as engineering achievements are. For example, about one-third of the respondents feel that it is very important to advance to a policy-making position in management.

PRESENTATION OF THE DATA

We grouped survey responses from the AIAA student study into four broad categories: technical communications skills, information resources and products, computers and electronic networks, and libraries. We present data for each category.

Technical Communications Skills

Students were given a list of six technical communications skills and asked to indicate the importance of each skill to their professional success (table 2). The effective use of computer, communication, and information technology was considered very important by 91% of the students. The effective communication of technical information in writing or orally was rated important by about 84% of the students. Knowledge and understanding of engineering and science information resources and materials was considered important by about 80% of the students. About 64% indicated that knowing how to use a library containing engineering and science information resources and materials was important to their professional success. Slightly more than half (51%) of the students indicated that the ability to search electronic (bibliographic) data bases was important to their professional success as aerospace engineers.

Next, we determined if students had received instruction in six technical communications skills, and we asked students who had received the instruction to rate its helpfulness (table 3). Most of the students had received some form of instruction in the six technical communications skills. About 83% of the students had received instruction in using computer, communication, and information technology. About 72% had received instruction in technical writing/communication. About 64% had received instruction in using engineering/science information resources and materials. About 62% had received instruction in speech/oral communication. About 60% had received instruction in using a library that contains engineering/science information resources and materials. Finally, half of the students (50%) had received instruction in searching electronic (bibliographic) data bases.

Table 2. Importance of Selected Technical Communications Competencies to the Professional Success of U.S. Aerospace Engineering Students

Competencies	Percentage*	Number
Effectively communicate technical information in writing	83.8	1449
Effectively communicate technical information orally	83.7	1446
Have a knowledge and understanding of engineering/ science information resources and materials	80.3	1382
Ability to search electronic (bibliographic) data bases	51.4	874
Ability to use a library that contains engineering/science information resources and materials	63.9	1101
Effectively use computer, communication, and information technology	90.9	1573

* Students used a 7-point scale, where "7" is the highest rating, to evaluate importance. Totals include combined "6" and "7" responses.

Table 3. Skill Instruction Received and Helpfulness of Instruction for U.S. Aerospace Engineering Students

	Received		Helpfulness	
Skill Instruction	Percentage	Number	Percentage*	Number
Technical writing/ communication	72.2	1250	53.7	670
Speech/oral communication	62.2	1076	53.8	587
Using a library containing engineering/science information resources and materials	59.9	1037	39.4	411
Using engineering/science information resources and materials	63.6	1100	44.7	494
Searching electronic (bibliographic) data bases	50.2	869	41.3	372
Using computer, communication, and information technology	82.9	1433	68.4	968

* Students used a 7-point scale, where "7" is the highest rating, to evaluate helpfulness. Totals include combined "6" and "7" responses.

Only about one-half of the students who had received instruction in the six technical communication skills rated it helpful. The exception was the instruction the students had received in using computer, communication, and information technology; about 68% indicated that the instruction was helpful. Of the six technical communications skills in which students received instruction, that which the students received in using a library containing engineering/science information resources and materials was rated lowest (39.4%) in terms of helpfulness.

Information Resources and Products

Student respondents were given a list of seven information sources and a list of 17 information products. They were asked to indicate the "frequency of use" and the "importance" of each information source and product (table 4 and table 5). Students used a 5-point scale to measure use and a 7-point scale to measure importance.

Table 4. Sources Used to Meet the Information Needs of U.S. Aerospace Engineering Students

Sources	Use		Importance	
	Percentage*	Number	Percentage**	Number
Your personal collection of information	76.6	1314	70.3	1207
Other students	44.5	763	34.5	592
Faculty members	40.8	698	46.8	805
Library	40.2	688	40.0	687
Librarian	4.2	72	6.8	116
Your personal contacts within industry	9.0	154	12.6	216
Your personal contacts at government laboratories	6.2	107	10.8	185

* Totals for use include combined "4" and "5" responses.
** Totals for importance include combined "6" and "7" responses.

The aerospace engineering students in this study appear to rely on their personal collections of information (76.6%), other students (44.5%), faculty members (40.8%), and the library (40.2%) as sources of information. With the exception of their personal collections of information, use and relative importance for the remaining sources are approximately equal. Two data points are noteworthy. One is the relatively low use and importance assigned to "librarian" (4.2%); second is the noticeable lack of use by students of information sources outside of their knowledge community (personal contacts within industry, 9.0%, and at government laboratories, 6.2%).

These same students tend to make the greatest use of and assign the highest importance ratings to textbooks (84% use and 72.6% importance), computer programs and documentation (48.9% use and 44.5% importance), journal articles (42.4% use and 41.5% importance), and handbooks (30.1% use and 32.8% importance) (see table 5). Information products such as technical reports that would connect students to other knowledge communities were used infrequently and were accorded low importance by the students in this study. U.S. government technical reports were used by 26.9% of the respondents and rated important by 28.8%; U.S.

industry technical reports were used by 6.9% and rated important by 14.0%; foreign language technical reports were used by 1.5% and rated important by 3.4%.

Table 5. Products Used to Meet the Information Needs of US Aerospace Engineering Students

Products	Use		Importance	
	Percentage*	Number	Percentage**	Number
Abstracts	17.9	306	17.7	300
Conference/meeting papers	27.3	468	28.0	477
Journal articles	42.4	726	41.5	707
Handbooks	30.1	514	32.8	556
Textbooks	84.0	1442	76.2	1299
Computer programs and documentation	48.9	841	44.5	756
Bibliographic, numeric, and factual data bases	12.3	210	15.8	268
Theses/dissertations	9.8	168	14.4	244
U.S. government technical reports	26.9	460	28.8	488
Audio/visual materials	6.6	113	8.3	141
Foreign language technical reports	1.5	26	3.4	58
Technical translations	1.2	21	4.2	71
Patents	0.6	10	3.2	55
U. S. industry technical reports	6.9	118	14.0	238
Drawings/specifications	11.1	188	13.6	230
Preprints or deposited manuscripts	2.3	39	5.1	86
Informal information products (e.g., Vendor/supply catalogs, company literature, trade journals)	20.0	341	17.8	303

Computer and Electronic Networks

About 81% of the student respondents used electronic networks (table 6). About 72% use them personally, and about 9% use them through an intermediary. About 4% did not use electronic networks, about 5% do not have access to them, and about 10% may use electronic networks in the future. About 90% of the respondents use electronic networks to send and receive e-mail. About 79% use electronic networks to access/search the library's catalog, and 72% use them to log onto computers for such things as computational analysis and design tools. However, only about 19% use electronic networks to order documents from the library. About 64% use electronic networks to connect to geographically distant sites; however, only about 15% of the student respondents use electronic networks to prepare papers collaboratively with colleagues at geographically distant sites.

About 83% of the student respondents use electronic networks to exchange files with members of their academic classes. About 63% use electronic networks to exchange files with people at their same academic site who are not in their academic classes. About 50% of the student respondents use electronic networks to exchange files with other people in the academic

community at a different geographic site, who are not in their academic classes, and about 59% use them to exchange files with people outside of their academic community.

Table 6. Use of Electronic Networks for Specific Purposes by U.S. Aerospace Engineering Students

Factor	Percentage	Number
Use		
Do you use electronic networks?		
Yes, I personally use them	71.7	1237
Yes, I use them but through an intermediary	9.4	163
No	4.1	70
No, I do not have access to electronic networks	5.2	89
No but I may use them in the future	9.7	167
Purpose Of Use		
Connect to geographically distant sites	63.6	879
Electronic mail	90.1	1251
Electronic bulletin boards or conferences	52.0	716
Electronic file transfer	79.4	1095
Log on for computational analysis/design tools	71.9	997
Control laboratory instruments/machine tools	16.7	229
Access/search the library's catalog	78.9	1093
Order documents from the library	19.4	267
Search electronic (bibliographic) data bases	57.7	795
Information search and data retrieval	58.1	800
Prepare papers with colleagues at distant sites	14.9	206
Exchange With		
Members of your academic classes	82.7	1150
Other people in your academic community at the **SAME** geographic site who are not in your academic classes	62.8	869
Other people in your academic community at a **DIFFERENT** geographic site	50.3	692
People outside of your academic community	59.2	817

Libraries

About one-third of the student respondents indicated that they had "always" or "frequently" used either a public or a school library during high school. They had used a library an average of 9.7 times during the current school term (table 7). Students were also asked to rate the effectiveness of the information they had obtained from the library they had used in meeting their information needs. About 7% of the student respondents indicated that the information received from the library was very effective in meeting their information needs. About 56% stated that the information received from the library was neither effective nor ineffective, and about 37% stated that the information was very ineffective. Student respondents who had not used a library during the current school term were asked to give their reason(s) for non-use. Three reasons for non-use predominate: (1) my information needs were more easily met some other way (67%); (2) I had no information needs (51%); and (3) the library did not have the information I needed (42%).

Table 7. Frequency of Use of A Library This School Term by U.S. Aerospace Engineering Students

Library Use	Percentage	Number
0 Times	11.1	182
1 - 5 Times	40.5	666
6 - 10 Times	23.5	387
11 - 25 Times	18.1	298
26 - 50 Times	6.3	103
51 Or More Times	0.5	9
Mean	9.71	
Median	5.00	

Finally, student respondents were asked to select from a list of options the one that best characterized their method of searching electronic (bibliographic) data bases (table 8). About 79% of the respondents indicated that they do all or most of their own searching. About 42% do all of their own searching, and about 37% do most of their own searching. About 3% indicated that they use an intermediary (i.e., a librarian) to do all or most of their searching. About 9% indicated that they do not use electronic (bibliographic) data bases, and about 3% indicated that they do not have access to electronic (bibliographic) data bases.

Table 8. How U.S. Aerospace Engineering Students Search Electronic (Bibliographic) Data Bases

Method	Percentage	Number
I do all searches myself	41.9	721
I do most searches myself	36.5	628
I do half by myself and half through a librarian	6.0	103
I do most searches through a librarian	2.3	40
I do all searches through a librarian	0.8	14
I do not use electronic data bases	9.1	157
I do not have access to electronic data bases	3.3	56

DISCUSSION

To place the results of the student study in perspective, we compared the findings of the study with those of a study of practicing U.S. aerospace engineers [7] to look at potential differences between the practices of students and engineering professionals employed in industry and government.

• The engineering professionals indicated that the ability to communicate technical information effectively is very important for professional success. Almost three-quarters of them had received technical communications instruction while enrolled in school or after graduation. The student respondents also believe that the ability to communicate technical information effectively is

important for professional success. Almost three-quarters of them had received instruction in communicating technical information, and slightly more than half of them found it helpful.

• Aerospace engineering professionals in industry and government and the students in this study exhibit similar patterns of behavior when seeking information. Both groups first consult their personal stores of technical information, then speak with peers within their organization, next consult peers outside their organization, and lastly, consult libraries and librarians.

• About 90% of the aerospace engineering professionals in industry and government use electronic (computer) networks and find their use important in performing professional duties. They use electronic networks primarily for (1) electronic file transfer, (2) e-mail, and (3) to log on to remote computers for computational analysis/design tools. About 80% of the students reported using electronic (computer) networks, and their uses are very similar to those of the engineering professionals surveyed.

• About two-thirds of the aerospace engineering professionals in industry and government indicated that their organizational libraries were very important to them in the performance of their professional duties. When non-users were asked their reasons for non-use, they indicated (1) they had no information needs or (2) their information needs were more easily met with sources other than those offered by the library. About two-thirds of the student respondents indicated that knowing how to use a library containing engineering/science information resources and materials was important to their professional success. Not quite 60% of them had received library skills instruction, however, and of those who had received instruction, only 39% found it helpful. When student non-users were asked their reasons for non-use of the library, they indicated (1) they had no information needs or (2) their information needs were more easily met with sources other than those offered by the library.

CONCLUDING REMARKS

The communication of technical information is an essential element of successful aerospace engineering practice. Because effective communication is fundamental, important questions arise about what communications skills should be taught to aerospace engineering students, when those skills should be taught, how much instruction is necessary, and how effective the instruction is. The results of the AIAA student study provide some insight. For example, the respondents realize the importance of communications skills and effective communication to professional success. About two-thirds of the students surveyed had received some form of communications skills instruction. Of those who had received instruction, slightly less than half found it helpful. What is missing is an understanding of whether instruction is offered but students elect not to take it; how much, if any, is required; and finally, how relevant any of the instruction is for meeting the day-to-day communications needs of engineering professionals.

What is needed to answer these questions is (1) a clear explanation from the professional engineering community about what constitutes acceptable and desirable communications norms within that community, (2) adequate and generalizable data from engineering students about the communications skills instruction they receive, (3) adequate and generalizable data from entry-level engineers about the adequacy and usefulness of the instruction they received as students, and (4) a higher level theoretical framework -- a comprehensive understanding of the nature of knowledge and learning -- within which the interpretation of such data can take on consistent and

full meaning. Two studies could be undertaken to provide additional data. One would be a survey of aerospace engineering course descriptions for implicit or explicit indicators of instruction in communications skills and the use of information resources. The second would be a survey of entry-level aerospace engineers to determine their communications patterns and behaviors during their first few years on the job.

REFERENCES

[1] Lawrence, B. (1988). "Educational uses of the aerospace database." AIAA-88-0749. AIAA 26th Aerospace Sciences Meeting, Reno, NV.

[2] Pelton, J. N. (1990). "A satellite-based global education system: The knowledge network of the world." IAF-90-477. 41st Congress of the International Astronautical Federation, Dresden, GDR.

[3] Willekens, P., and Abrams, S. (1993). "ISUNET: The information system built for world-wide space education based on existing tools and experience of the space community." IAF-93-P.2.363. 44th Congress of the International Astronautical Federation, Graz, Austria.

[4] Lo, R., et al. (1993). "Hands-on keyboard: The multi-functional tutorial for teaching and practical instruction of space-technology students." IAF-93-P-1-356. 44th Congress of the International Astronautical Federation, Graz, Austria.

[5] Pinelli, T. E.; Kennedy, J. M.; and Barclay, R. O. (1991). "The NASA/DoD Aerospace Knowledge Diffusion Research Project." *Government Information Quarterly 8*(2): 219-233.

[6] Holland, M. P.; Pinelli, T. E.; Barclay, R. O.; and Kennedy, J. M. (1991). "Engineers as information processors: A survey of U.S. aerospace engineering faculty and students." *European Journal of Engineering Education 16*(4): 317-336.

[7] Pinelli, T. E.; Glassman, M.; Oliu, W. E.; and Barclay, R. O. (1989). *Technical Communication in Aerospace: Results of a Phase I Pilot Study*. Washington, DC: NASA. NASA TM-101534.